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(Translation)

**APPLICATION FOR PATENT**

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**TITLE OF INVENTION:** **INLINE SYSTEM AND METHOD FOR MANUFACTURING  
LIQUID CRYSTAL DISPLAYS**

Submitted herewith is/are an application identified above pursuant to  
Article 42 of the Patent Act.

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To the Commissioner of  
the Korean Industrial Property Office

Attachment: 1. Abstract, specification (and drawing) - one copy each

KOREAN INDUSTRIAL PROPERTY OFFICE

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Application Number: Patent Application No. 2000-21079

Date of Application: April 20, 2000

Applicant(s): Samsung Electronics Co., Ltd.(LCD Business)

COMMISSIONER

## **[ABSTRACT OF THE DISCLOSURE]**

### **[ABSTRACT]**

Disclosed is an in-line system and method for manufacturing liquid crystal displays. The system includes a spacer-dispersing unit for dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region; a sealant-applying unit for depositing a sealant on one of the two substrates; a liquid crystal depositing unit for depositing liquid crystal material on the substrate on which the sealant is deposited; and a substrate-attaching unit for receiving the two substrates from the sealant-applying unit or the liquid crystal depositing unit, then conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel. The method includes the steps of dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region; depositing a sealant on one of the two substrates; depositing liquid crystal material on the substrate on which the sealant is deposited; and conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel.

**[SPECIFICATION]**

**[TITLE OF THE INVENTION]**

**IN-LINE SYSTEM AND METHOD FOR MANUFACTURING LIQUID CRYSTAL  
DISPLAYS**

**[BRIEF DESCRIPTION OF THE DRAWINGS]**

FIG. 1 is a plan view of a liquid crystal panel produced using an in-line system according to a preferred embodiment of the present invention;

FIG. 2 is a sectional view taken along line II-II' of FIG. 1;

FIG. 3 is a schematic block diagram of an in-line system for manufacturing liquid crystal displays according to a preferred embodiment of the present invention;

FIGs. 4a and 4b are sectional views of a spacer according to a preferred embodiment of the present invention;

FIGs. 5a and 5b are plan views of a substrate for showing the formation of a sealant during manufacture of a liquid crystal display according to a preferred embodiment of the present invention;

FIGs. 6a – 6c are sectional views showing the sequential steps involved in hardening a sealant during manufacture of a liquid crystal display according to a preferred embodiment of the present invention;

FIGs. 7a and 7b are views for describing the depositing of liquid crystal material during manufacture of a liquid crystal display according to a preferred embodiment of the present invention;

FIGs. 8a – 9b are views for describing the adhering of a substrate on a pressure plate during manufacture of a liquid crystal display according to a preferred embodiment of the present invention;

FIGs. 10 – 12 are views showing a structure of a substrate-attaching unit in an

in-line system according to different embodiments of the present invention;

FIGs. 13a – 13f are plan views of a compression plate in a substrate-attaching unit according to a preferred embodiment of the present invention; and

FIG. 14 is a schematic view of an in-line system having a plurality of substrate-attaching units according to another embodiment of the present invention.

## **[DETAILED DESCRIPTION OF THE INVENTION]**

### **[OBJECT OF THE INVENTION]**

### **[FIELD OF THE INVENTION AND CONVENTIONAL ART IN THE FIELD]**

The present invention relates to a system and method for manufacturing liquid crystal displays.

A liquid crystal display (LCD) is structured having liquid crystal material injected between two substrates. The two substrates have electrodes formed on an inner surface thereof and are joined using a sealant. A plurality of spacers are provided between the substrates to maintain a predetermined cell gap. The liquid crystal material sandwiched between the substrates has the property of being dielectrically anisotropic such that when a voltage of a different potential is applied to electrodes of the substrates to form an electric field, the alignment of liquid crystal molecules of the liquid crystal material is varied. Accordingly, the transmittance of incident light is controlled to enable the display of images.

To manufacture the LCD, orientation layers for orienting the liquid crystal molecules of the liquid crystal material are first provided on the substrates, and an orientation process is performed. Next, spacers are dispersed on one of the substrates, then the sealant is applied to outer edges of the substrates. The sealant is provided with a hole through which the liquid crystal material is to be injected. Following this step, the substrates are aligned then attached through a hot press process. Next, liquid crystal material is injected through the hole of the sealant, after which the hole is sealed.

In the LCD manufacturing process, a plurality of liquid crystal cells, each for producing a single LCD, are formed from a single mother glass. Before the injection of the liquid crystal material, the mother glass is divided into 4, 6 or 8 liquid crystal cells

(but not yet cut into these divisions), after which the process is continued on the individual liquid crystal cells.

A serious drawback of the conventional LCD manufacturing process is that it is time-consuming. In particular, the injection of the liquid crystal material must be performed in a state where there is a vacuum formed between the substrates. The formation of this vacuum while ensuring that the cell gap is maintained, and the subsequent step of injecting the liquid crystal material through the small injection hole are both processes that require a substantial amount of time. Further, since the time required for each individual process may vary according to, for example, the drive method used for a particular LCD, and since there occurs a switch during production from processes performed on the mother glass to those performed on the individual liquid crystal cells, it becomes difficult to provide production equipment for the specific processes in an in-line configuration or to automate manufacture. Therefore, there are substantial limitations as to how much productivity can be improved. Also, during injection of the liquid crystal material, the spacers become re-positioned by the forces generated from the flow of the liquid crystal material, thereby making a uniform cell gap difficult to obtain.

#### **[TECHNICAL TASK OF THE INVENTION]**

The present invention has been made in an effort to solve the above problems.

It is an object of the present invention to provide an in-line system and method for manufacturing liquid crystal displays.

It is another object of the present invention to simplify a method for manufacturing a liquid crystal display, and to minimize manufacturing costs and reduce the time required for



manufacture.

It is another object of the present invention to improve yield of method of manufacturing liquid crystal displays.

#### **[CONFIGURATION AND OPERATION OF THE INVENTION]**

The in-line system comprises a spacer-dispersing unit for dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region; a sealant-applying unit for depositing a sealant on one of the two substrates; a liquid crystal depositing unit for depositing liquid crystal material on the substrate on which the sealant is deposited; and a substrate-attaching unit for receiving the two substrates from the sealant-applying unit or the liquid crystal depositing unit, then conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel.

According to a feature of the present invention, the in-line system further comprises a first loading unit on which one of the two substrates is loaded, and a second loading unit on which one of the two substrates is loaded; and a substrate-combination unit for providing the two substrates to the substrate-attaching unit.

According to another feature of the present invention, the in-line system further comprises a sealant heat-treating unit for forming a reaction-preventing layer on a surface of the sealant such that a reaction between the sealant and the liquid crystal material is prevented.

According to yet another feature of the present invention, the first loading unit, the spacer-dispersing unit, the sealant-applying unit, the liquid crystal depositing unit, the substrate-combination unit, and the substrate-attaching unit are combined in this

sequence through first, second, third, fourth and fifth in-line conveying units, which transport the substrates to these elements in predetermined in-line process time units.

According to still yet another feature of the present invention, the second loading unit is connected to the substrate-combination unit through a sixth in-line conveying unit.

According to still yet another feature of the present invention, the first loading unit, the sealant-applying unit, the liquid crystal depositing unit, the substrate-combination unit, and the substrate-attaching unit are combined in this sequence through first, second, third and fourth in-line conveying units, which transport the substrates to these elements in predetermined in-line process time units.

According to still yet another feature of the present invention, the second loading unit, the spacer-dispersing unit and the substrate-combination unit are connected in sequence through fifth and sixth in-line conveying units.

According to still yet another feature of the present invention, the substrate-attaching unit includes two or more vacuum chambers for conjoining the substrates in a vacuum state in a predetermined in-line process time unit.

According to still yet another feature of the present invention, the vacuum chambers are connected in series such that the substrates are provided to a subsequent process in a predetermined vacuum state, each vacuum chamber holding the substrates for a predetermined in-line process time.

According to still yet another feature of the present invention, the vacuum chambers are connected in parallel such that the substrates are provided to a subsequent process in a predetermined vacuum state, each vacuum chamber holding

the substrates for a predetermined in-line process time.

According to still yet another feature of the present invention, the substrate-attaching unit includes first and second compression plates for supporting the two substrates and applying a predetermined force toward each other such that the substrates are pressed together; and an exposure unit for hardening the sealant.

According to still yet another feature of the present invention, the substrate-attaching unit includes first and second compression plates for supporting the two substrates and applying a predetermined force toward each other such that the substrates are pressed together, the first and second compression plates having at least one vacuum hole for exhausting air from between the compression plates; a support tube provided between the compression plates for sealing a space therebetween, the support tube having an inner space from which air can be exhausted such that an interval between the compression plates can be adjusted; and an exposure unit for hardening the sealant.

According to still yet another feature of the present invention, there are provided a plurality of the vacuum holes at predetermined locations, and air is exhausted from the vacuum holes in a predetermined sequence.

According to still yet another feature of the present invention, the vacuum holes are formed at corners or center portions of each side of the first and second compression plates.

According to still yet another feature of the present invention, the vacuum holes are shaped as slits of a predetermined length.

According to still yet another feature of the present invention, the liquid crystal

depositing unit includes a liquid crystal depositer that is a syringe-type device such that the liquid crystal material can be deposited at specific predetermined locations in the liquid crystal cell regions.

According to still yet another feature of the present invention, the liquid crystal depositing unit is a spray-type device such that the liquid crystal material can be deposited over an entire surface of the liquid crystal cell regions.

According to still yet another feature of the present invention, the sealant-applying unit deposits the sealant in a closed loop, that is, without a liquid crystal injection hole.

According to still yet another feature of the present invention, the sealant is a material that is hardened by infrared rays.

According to still yet another feature of the present invention, the sealant includes one or more buffer regions that have a predetermined area to allow for flow of excess liquid crystal material.

The method comprises the steps of dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region; depositing a sealant on one of the two substrates; depositing liquid crystal material on the substrate on which the sealant is deposited; and conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel.

According to a feature of the present invention, the method further comprises the step of forming a reaction-preventing layer on a surface of the sealant by a first hardening process such that a reaction between the sealant and the liquid crystal material is prevented.

According to another feature of the present invention, the steps of dispersing the spacers, depositing the sealant, depositing the liquid crystal material and conjoining the substrates are performed as in-line processes.

According to yet another feature of the present invention, the steps of dispersing the spacers, depositing the sealant and depositing the liquid crystal material are performed on one of the two substrates.

According to still yet another feature of the present invention, the steps of dispersing the spacers and depositing the sealant are performed on one substrate, and the step of depositing the liquid crystal material is performed on the other substrate.

According to still yet another feature of the present invention, in the step of conjoining the substrates, the vacuum state is generated in multiple steps of predetermined in-line process time units.

According to still yet another feature of the present invention, in the step of conjoining the substrates, the two substrates are provided in the vacuum state in a predetermined in-line process time unit.

According to still yet another feature of the present invention, the step of conjoining the substrates includes the steps of aligning the substrates, applying a predetermined force to the substrates in a direction toward each other such that the substrates are attached by the sealant, and exposing the sealant and performing a second hardening process on the sealant.

According to still yet another feature of the present invention, the step of conjoining the substrates includes the steps of aligning the substrates, forming a vacuum between the substrates, reducing a space between the substrates by

controlling the vacuum, applying a predetermined force to the substrates in a direction toward each other such that the substrates are attached by the sealant, and exposing the sealant and performing a second hardening process on the sealant.

According to still yet another feature of the present invention, the step of forming the vacuum is performed through a plurality of the vacuum holes formed at predetermined locations.

According to still yet another feature of the present invention, the step of forming the vacuum is performed by exhausting air from the vacuum holes in a predetermined sequence.

According to still yet another feature of the present invention, the step of depositing the liquid crystal material includes the steps of providing droplets of the liquid crystal material at predetermined locations, and rotating the substrate.

According to still yet another feature of the present invention, the step of depositing the liquid crystal material includes the step of depositing the liquid crystal material over an entire surface of the liquid crystal cell regions.

According to still yet another feature of the present invention, in the step of depositing the sealant, the sealant is deposited in a closed loop, that is, without a liquid crystal injection hole.

According to still yet another feature of the present invention, the sealant is a material that is hardened by infrared rays.

According to still yet another feature of the present invention, the sealant includes one or more buffer regions that have a predetermined area to allow for flow of excess liquid crystal material.

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. 1 shows a plan view of a liquid crystal panel produced using an in-line system according to a preferred embodiment of the present invention, and FIG. 2 shows a sectional view taken along line II-II' of FIG. 1.

A liquid crystal panel 100, which is realized through a single mother glass that has undergone liquid crystal injection and substrate-attachment processes, includes a plurality of liquid crystal cells. For example, four liquid crystal cell regions 111, 121, 131 and 141 are formed in the liquid crystal panel 100. The liquid crystal panel 100 includes insulation substrates 110 and 120 opposing each other and a liquid crystal layer 130, which is formed of liquid crystal material injected between the substrates 110 and 120. Spherical spacers 140 are mixed in with the liquid crystal layer 130. The spacers 140 maintain a predetermined cell gap between the substrates 110 and 120 such that the substrates 110 and 120 are substantially parallel. Further, a sealant 150 is formed around edges of each liquid crystal cell such that the liquid crystal layer 130 is sealed between the substrates 110 and 120. Spacers may also be mixed in with the sealant 150.

As described above, the liquid crystal layer 130 is injected in a state where the liquid crystal panel 100 is not divided into liquid crystal cells. The division takes place along cut lines a and b, and the cutting into separate cells occurs only after both liquid crystal injection and substrate-attachment processes have been completed.

There may be formed on the substrates 110 and 120 of the liquid crystal panel 100 wiring for transmitting electrical signals such as scanning signals and image signals,

and which intersect to define pixel regions; thin film transistors, which are switching devices for controlling image signals; pixel electrodes and a common electrode for forming an electric field to drive liquid crystal molecules of the liquid crystal material; and a RGB color filter, which is needed for the display of images.

FIG. 3 shows a schematic block diagram of an in-line system for manufacturing liquid crystal displays according to a preferred embodiment of the present invention.

As shown in the drawing, an in-line system for manufacturing liquid crystal displays according to a preferred embodiment of the present invention includes a first loading unit 1000, a spacer-dispersing unit 2000, a sealant-applying unit 3000, a sealant heat-treating unit 4000, a liquid crystal depositing unit 5000 having a liquid crystal depositer 5100, a substrate-combination unit 6000, a second loading unit 7000, a substrate-attaching unit 8000, and an unloading unit 9000. Provided between the first loading unit 1000, the spacer-dispersing unit 2000, the sealant-applying unit 3000, the sealant heat-treating unit 4000, the liquid crystal depositing unit 5000, the substrate-combination unit 6000, the substrate-attaching unit 8000, and the unloading unit 9000 are in-line conveying units 1110, 1120, 1130, 1140, 1150, 1170 and 1180 for conveying the substrates 110 and 120 from one process to the next. The second loading unit 7000 is connected to the substrate-combination unit 6000 through an in-line conveying unit 1160. Since the attachment of the substrates 110 and 120 at the substrate-attaching unit 8000 occurs in a state where a vacuum is formed between the substrates 110 and 120, the in-line conveying units 1170 and 1180 may include vacuum chamber connecting means.

Manufacture of a liquid crystal display using the in-line system above will now be



described.

First, the substrate 110, which is loaded on the first loading unit 1000, is transported to the spacer-dispersing unit 2000 via the in-line conveying unit 1110. The spacers 140 are dispersed at a predetermined density on an inner face of the substrate 110 at the spacer-dispersing unit 2000. At this time, it is preferable that the spacers 140 be spherical or cylindrical and have a diameter that is 10-30% greater than the desired cell gap between the substrates 110 and 120. Further, if the spacers 140 are simply dispersed without securing the same to the substrate 110, external shocks applied during manufacture or the flow of the liquid crystal material during the depositing of the same may displace the spacers 140 from their intended positions, thereby resulting in a non-uniform cell gap between the substrates 110 and 120. Accordingly, it is preferable that the spacers 140 are adhered to the substrate 110 after being dispersed.

With reference to FIG. 4a, this is realized in the present invention by coating the spacers 140 with an adhesive 142, which is made from an epoxy group polymer. Next, infrared rays are irradiated onto the substrate 100 and the spacers 140 dispersed thereon such that the adhesive 142, with reference to FIG. 4b, on an upper portion of the spacers 140 melts and flows downward to fully surround a lower portion of the spacers 140. Accordingly, the spacers 140 are fixed to their positions on the substrate 110. Instead of dispersing the spacers 140 in this manner, it is possible to form the spacers 140 through a photolithography process. This may also include the formation of the spacers 140 in the sealant. Such an alternative process is particularly advantageous for large substrates.

Following the above, the substrate 110 is transported from the spacer-dispersing

unit 2000 to the sealant-applying unit 3000 via the in-line conveying unit 1120. The sealant 150 is deposited on the substrate 110 at the sealant-applying unit 3000. The sealant 150 is formed in a closed configuration, that is, the sealant 150 does not include a liquid crystal injection hole as in the prior art. Also, the sealant 150 may be realized through a heat-hardening material or an infrared ray-hardening material, and may include spacers for better maintaining the cell gap between the substrates 110 and 120.

Since there is no liquid crystal injection hole formed in the sealant 150, the amount of liquid crystal material provided between the substrates is difficult to control. Too much liquid crystal material leads to damage to the sealant 150, while an insufficient amount of liquid crystal material results in areas that are not fully filled with the liquid crystal material. To solve this problem, it is preferable that a buffer region(s) is formed in the sealant 150 such that liquid crystal material fully fills display portions and any excess liquid crystal material flows into the buffer region(s). With reference to FIG. 5a, at least one buffer region 151 is formed in the sealant 150. When the amount of liquid crystal material provided to the substrate 110 surpasses that needed to fill a display region c, the excess liquid crystal material flows into the buffer region 151. As another example, with reference to FIG. 5b, buffer regions 152, which allow the inflow of excess liquid crystal material, are formed around a circumference of the display region c. It is preferable that the amount of liquid crystal material deposited during a subsequent liquid crystal depositing process is in excess of an amount needed to fill the display region c and less than a volume defined by the sealant 150.

Next, the substrate 110 is transported from the sealant-applying unit 3000 to the sealant heat-treating unit 4000 by the in-line conveying unit 1130. It is preferable that a

reaction prevention layer is formed on a surface of the sealant 150 through an exposure or heat-treating process such that no reaction takes place between the liquid crystal layer 130 and the sealant 150. For this purpose, it is preferable that an infrared ray-hardening material is used for the sealant 150. During a first hardening process, the sealant 150, with reference to FIG. 6a, is divided into a portion 155 that is hardened and is comprised of the reaction prevention layer, and a portion 157 that has not been hardened.

During an initial stage of a substrate-attachment process, which is to be performed at a later point in the production process, with reference to FIG. 6b, the reaction prevention layer of the portion 155 on the surface of the sealant 150 is pressed by the conjoining of the substrates 110 and 120. Further, during a second hardening process with reference to FIG. 6c, infrared rays are irradiated onto the substrates 110 and 120 such that the sealant 150 is fully hardened, thereby completing the attachment of the substrates 110 and 120 to one another.

Before the attachment of the substrates 110 and 120, however, the substrate 110 is transported to the liquid crystal depositing unit 5000 from the sealant heat-treating unit 4000 via the in-line conveying unit 1140. Next, using the liquid crystal depositer 5100, predetermined amounts of the liquid crystal material are deposited such that the liquid crystal layer 130 is formed to correspond to the sizes of the liquid crystal cell regions 111, 121, 131 and 141. At this time, the liquid crystal depositer 5100, with reference to FIG. 7a, may be a syringe-type device such that liquid crystal material 132 is provided in specific areas, that is, in the liquid crystal cell regions 111, 121, 131 and 141. The liquid crystal depositer 5100 may also be a spray-type device, which includes

a jig 5110 and a nozzle 5120 connected to the jig 5110, which is able to provide the liquid crystal material 132 over an entire surface of the liquid crystal cell regions 111, 121, 131 and 141 as shown in FIG. 7b.

The case where the liquid crystal depositor 5100 is a syringe-type device is advantageous when the liquid crystal panel 100 of the mother glass is produced into a single liquid crystal cell. With this configuration, it is preferable that the substrate 110 is rotated at approximately 30-60rpm to reduce the time required to deposit the liquid crystal material 132. However, if the liquid crystal depositor 5100 is a spray-type device, the advantage of being able to adjust the depositing of the liquid crystal material 132 is realized. That is, the number of nozzles 5120 as well as an application length (d) may be controlled such that the liquid crystal depositor 5100 can be used for various sizes of liquid crystal cells.

In the prior art, liquid crystal material is injected using a liquid crystal injection hole in a state where a vacuum is formed in each of the liquid crystal cells. However, in the present invention, since the liquid crystal material 132 is either dispersed or deposited while the substrate 110 is being rotated, the time required for manufacture is reduced. Further, because the liquid crystal injection time varies in the prior art with changes in the size of the liquid crystal cells, as well as to the characteristics of the liquid crystal material, which occurs according to the drive method of the liquid crystal molecules, overall control of production is significantly diminished. In the present invention, on the other hand, the time used to supply the liquid crystal material 132 to the substrate 110 can be fixed regardless of liquid crystal cell size and characteristics of the liquid crystal material 132 since the liquid crystal material 132 is deposited or

dispersed.

Following the processes performed in the liquid crystal depositing unit 5000, the substrate 110 is transported to the substrate-combination unit 6000 via the in-line conveying unit 1150. At the same time, the substrate 120 loaded on the second loading unit 7000 is transported to the substrate-combination unit 6000 through the in-line conveying unit 1160.

Next, the two substrates 110 and 120 are transported to the substrate-attaching unit 8000, which is a vacuum chamber, via the in-line conveying unit 1170. The substrates 110 and 120 are attached to one another in a vacuum state in the substrate-attaching unit 8000, thereby completing the liquid crystal panel 100. The substrate-attaching unit 8000 includes a first compression plate 8100 and a second compression plate 8200, as shown in Fig. 3. The substrates 110 and 120 are mounted to the compression plates 8100 and 8200, respectively, such that they are aligned in parallel. Next, the compression plates 8100 and 8200 apply a uniform force toward each other such that the substrates 110 and 120 are pressed together. As a result of this force, the spacers 140 (see FIG. 2) dispersed on the substrate 110 (and provided in the sealant 150 in some cases) are deformed. Also resulting from the compression force, the liquid crystal material deposited on the substrate 110 is spread over the entire area of the liquid crystal cell regions 111, 121, 131 and 141 (see FIG. 1) to form the liquid crystal layer 130 (see FIG. 2).

Subsequently, after a force is applied by the compression plates 8100 and 8200 such that the desired gap is obtained between the substrates 110 and 120, an exposure unit (not shown) is used to irradiate infrared rays onto the substrates 110 and 120 for a

second hardening process such that the sealant 150 is fully hardened. Accordingly, the substrates 110 and 120 are conjoined as shown in FIG. 6. It is preferably that the substrates 110 and 120 be precisely aligned either during the process of compressing the substrates 110 and 120 or when performing the second hardening process. Also, it is preferable that an air pressurization method be used in order to apply an even pressure to the substrates 110 and 120.

In order to mount the substrates 110 and 120 respectively to the first and second compression plates 8100 and 8200, a point vacuum adhesion method or a planar vacuum adhesion method may be used. In the case where the point vacuum adhesion method is used, with reference to FIGs. 8a – 8c, pipes 8110 mounted to the first and second compression plates 8100 and 8200 at areas corresponding to corner portions of the substrates 110 and 120 are pressed against the substrates 110 and 120, then a vacuum is formed in an inside area 8111 of the pipes 8110. Accordingly, the substrates 110 and 120 are attached to the 8100 and 8200 as long as the vacuum is maintained.

With the application of the vacuum, center portions 112 and 122 respectively of the substrates 110 and 120 may become deformed as shown in FIG. 8b such that the precise alignment of the substrates 110 and 120 is not possible. To prevent this, it is preferable that a vacuum hole be formed in the compression plates 8100 and 8200 as shown in FIG. 8c so that a vacuum may be formed between the compression plates 8100 and 8200 and the substrates 110 and 120 by pumping the air out therebetween.

If the planar vacuum adhesion method is used, with reference to FIGs. 9a and 9b, a planar suction mechanism 8220 is provided on the compression plates 8100 and 8200.

The planar suction mechanism 8220 includes a plurality of openings 8221, which can be formed in a variety of shapes over the entire area of the planar suction mechanism 8220. After contacting the planar suction mechanism 8220 to the substrates 110 and 120, air is drawn inwardly through the openings 8221 to adhere the substrates 110 and 120 to the compression plates 8100 and 8200. The planar vacuum adhesion method is preferred over the point vacuum adhesion method for a variety of reasons. The substrates 110 and 120 are supported over an entire area thereof, application to a variety of sizes of substrates is easy, substrate deformation problems are avoided, and the substrates 110 and 120 are more rigidly attached to the compression plates 8100 and 8200.

After the above step, the conjoined substrates 110 and 120 (i.e., the completed liquid crystal panel 100) are transported to the unloading unit 9000 from the substrate-attaching unit 8000 through the in-line conveying unit 1180. Next, the liquid crystal panel 100 is transported to a cutting unit (not shown) where the liquid crystal panel 100 is cut into portions corresponding to the liquid crystal cell regions 111, 121, 131 and 141, thereby obtaining liquid crystal cells for LCDs.

In the manufacturing method of the present invention described above, a vacuum must be formed in order to attach the substrates 110 and 120 to one another. The time required for forming the vacuum is greater than that needed to disperse the spacers 140, deposit the sealant 150 or liquid crystal material, or in the actual conjoining of the substrates 110 and 120. Overall productivity is reduced as a result. To solve this problem, a method may be used in which a plurality of vacuum chambers are used. Also, there may be used a method in which the number of areas in which a vacuum

must be formed is minimized. This will be described in detail with reference to the drawings.

FIGs. 10 – 12 are views showing a structure of a substrate-attaching unit in an in-line system according to different embodiments of the present invention. Like reference numerals will be used for elements identical to those of the above embodiment.

First, with reference to FIG. 10, a substrate-attaching unit 8000 according to another embodiment includes first, second, third and fourth vacuum chambers 8300, 8400, 8500 and 8600; connecting units 8010, 8020 and 8030, which interconnect the vacuum chambers 8300, 8400, 8500 and 8600; a substrate-attaching vacuum chamber 8700; and a connecting unit 8040 connecting the substrate-attaching vacuum chamber 8700 to the fourth vacuum chamber 8600.

With this structure, the substrates 110 and 120 are moved in sequence through the first, second, third and fourth vacuum chambers 8300, 8400, 8500 and 8600, which generate an increasingly higher vacuum, such that the substrates 110 and 120 arrive at the substrate-attaching vacuum chamber 8700 in a desired vacuum state. The substrates 110 and 120 are aligned and conjoined in the substrate-attaching vacuum chamber 8700 using the methods described previously. As a result, the entire process in the in-line system is not backed up at the stage where a vacuum is formed, and the substrates 110 and 120 can be kept moving through the system, thereby improving productivity. Further, precise control is provided through this structure in that the number of vacuum chambers can be manipulated to correspond to a unit of time at each vacuum chamber that matches the time used in the other processes of the in-line



system.

According to yet another embodiment, with reference to FIG. 11, a substrate-attaching unit 8000 includes, as with the above embodiment, first, second, third and fourth vacuum chambers 8300, 8400, 8500 and 8600; and a substrate-attaching vacuum chamber 8700. However, the first, second, third and fourth vacuum chambers 8300, 8400, 8500 and 8600 are provided in parallel and are connected to the substrate-combination unit 6000 via the connecting units 1171, 1172, 1173 and 1174, respectively, and to the substrate-attaching vacuum chamber 8700 via the connecting units 1191, 1192, 1193 and 1194, respectively.

With this structure, a desired vacuum state is formed in each of the vacuum chambers 8300, 8400, 8500 and 8600, and the substrates 110 and 120 are supplied to the vacuum chambers 8300, 8400, 8500 and 8600 from the substrate-combination unit 6000 in sequence, then they are also supplied in sequence to the substrate-attaching vacuum chamber 8700. Accordingly, sufficient time is provided for each of the vacuum chambers 8300, 8400, 8500 and 8600 to generate the desired vacuum state, thereby preventing any back-up in the in-line system. In this embodiment also, the number of vacuum chambers may be adjusted as needed.

Referring now to FIG. 12, a substrate-attaching unit 8000 can be structured to perform a variety of processes on the substrates 110 and 120. That is, the substrate-attaching unit 8000 includes first and second compression plates 8100 and 8200, which have at least one vacuum hole 8900, and a support tube 8800 provided between the compression plates 8100 and 8200, and which seals the space therebetween.

With this configuration, the substrates 110 and 120 are first attached to the inner faces of the compression plates 8100 and 8200 using the methods described with reference to FIGs. 8a – 8c or 9a and 9b, then air between the compression plates 8100 and 8200 is exhausted through the vacuum hole 8900 until a vacuum of 0.1 Torr or less is formed between the compression plates 8100 and 8200. Next, the air within the support tube 8800 is slowly exhausted to decrease the interval between the compression plates 8100 and 8200 until the desired cell gap between the substrates 110 and 120 is obtained. Infrared rays are then irradiated onto the substrates 110 and 120 to harden the sealant 150, thereby completing the liquid crystal panel 100 of FIG. 1.

During the formation of a vacuum between the compression plates 8100 and 8200 by exhausting air from the vacuum hole 8900, if the liquid crystal material 132 gathers at edges of the substrate 110, an uneven cell gap between the substrates 110 and 120 may result. To solve this problem, it is preferable that a plurality of vacuum holes 8900 be provided in specific areas of the first and second compression plates 8100 and 8200, and the air is exhausted in sequence from the vacuum holes 8900 to generate the vacuum. The vacuum holes 8900 may be formed in corners of the compression plates 8100 and 8200 as shown in FIG. 13a, in center portions of side edges of the compression plates 8100 and 8200 as shown in FIG. 13b, or in both the corners and in center portions of the side edges of the compression plates 8100 and 8200 as shown in FIG. 13c. In addition, the vacuum holes 8900 may be formed as slits along sides of the compression plates 8100 and 8200 as shown in FIG. 13d, as slits around corners of the compression plates 8100 and 8200 as shown in FIG. 13e, or as slits both along the sides and the corners of the compression plates 8100 and 8200 with

predetermined distances therebetween as shown in FIG. 13f.

When exhausting air from the vacuum holes 8900 to form the vacuum between the compression plates 8100 and 8200, it is preferable that the vacuum holes 8900 be used in a sequence that is suitable for the viscosity of the liquid crystal material 132. The vacuum holes 8900 described in the various shapes and positions above can be provided in both or only one of the compression plates 8100 and 8200.

In the in-line system and manufacturing method of an LCD using the in-line system described above, the majority of the processes are performed on one of the substrates 110 and 120, after which the substrates 110 and 120 are attached to one another. That is, the spacers are dispersed, the sealant is formed, and the liquid crystal material is deposited on only the substrate 110. However, it is possible to disperse the spacers on one substrate then form the sealant and deposit the liquid crystal material on the other substrate. If this alternative method is used, the spacer-dispersing unit 2000 of FIG. 3 is connected between the second loading unit 7000 and the substrate-combination unit 6000 through in-line conveying units.

Further, the in-line system described above is designed with a single substrate-attaching unit 8000 having vacuum chambers. However, it is possible to provide a plurality of substrate-attaching units. This will be described in detail with reference to FIG. 14.

FIG. 14 shows a schematic view of an in-line system having a plurality of substrate-attaching units according to another embodiment of the present invention.

As shown in the drawing, the in-line system includes (a) a substrate-combination unit 6100 that is provided with the first substrate 110, on which are deposited the

sealant 150 and the liquid crystal material 132, and the second substrate 120, on which the spacers 140 are dispersed; and (b) a plurality of substrate-attaching units 8001, 8002 and 8003, which are each provided with a pair of substrates 110 and 120 for assembly from the substrate-combination unit 6100. The number of substrate-attaching units can be adjusted as needed. With this configuration, the in-line system can be kept operating without encountering delays as a result of the relatively slow processes involved with the substrate-attaching units.

Although preferred embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught which may appear to those skilled in the present art will still fall within the spirit and scope of the present invention, as defined in the appended claims.

#### **[ADVANTAGE OF THE INVENTION]**

As described above, according to the present invention, method of manufacturing liquid crystal displays is simplified. Thereby manufacturing cost and time are reduced and yield is improved.

[CLAIMs]

1. An in-line system for manufacturing liquid crystal displays comprising:  
a spacer-dispersing unit for dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region;  
a sealant-applying unit for depositing a sealant on one of the two substrates;  
a liquid crystal depositing unit for depositing liquid crystal material on the substrate on which the sealant is deposited; and  
a substrate-attaching unit for receiving the two substrates from the sealant-applying unit or the liquid crystal depositing unit, then conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel.
2. The in-line system of claim 1 further comprising:  
a first loading unit on which one of the two substrates is loaded, and a second loading unit on which one of the two substrates is loaded; and  
a substrate-combination unit for providing the two substrates to the substrate-attaching unit.
3. The in-line system of claim 2 further comprising a sealant heat-treating unit for forming a reaction-preventing layer on a surface of the sealant such that a reaction between the sealant and the liquid crystal material is prevented.
4. The in-line system of claim 3 wherein the first loading unit, the spacer-dispersing unit, the sealant-applying unit, the liquid crystal depositing unit, the substrate-combination unit, and the substrate-attaching unit are combined in this sequence through first, second, third, fourth and fifth in-line conveying units, which transport the substrates to these elements in predetermined in-line process time units.

5. The in-line system of claim 4 wherein the second loading unit is connected to the substrate-combination unit through a sixth in-line conveying unit.

6. The in-line system of claim 3 wherein the first loading unit, the sealant-applying unit, the liquid crystal depositing unit, the substrate-combination unit, and the substrate-attaching unit are combined in this sequence through first, second, third and fourth in-line conveying units, which transport the substrates to these elements in predetermined in-line process time units.

7. The in-line system of claim 6 wherein the second loading unit, the spacer-dispersing unit and the substrate-combination unit are connected in sequence through fifth and sixth in-line conveying units.

8. The in-line system of claim 1 wherein the substrate-attaching unit includes two or more vacuum chambers for conjoining the substrates in a vacuum state in a predetermined in-line process time unit.

9. The in-line system of claim 8 wherein the vacuum chambers are connected in series such that the substrates are provided to a subsequent process in a predetermined vacuum state, each vacuum chamber holding the substrates for a predetermined in-line process time.

10. The in-line system of claim 8 wherein the vacuum chambers are connected in parallel such that the substrates are provided to a subsequent process in a predetermined vacuum state, each vacuum chamber holding the substrates for a predetermined in-line process time.

11. The in-line system of claim 1 wherein the substrate-attaching unit includes first and second compression plates for supporting the two substrates and applying a

predetermined force toward each other such that the substrates are pressed together; and an exposure unit for hardening the sealant.

12. The in-line system of claim 1 wherein the substrate-attaching unit includes first and second compression plates for supporting the two substrates and applying a predetermined force toward each other such that the substrates are pressed together, the first and second compression plates having at least one vacuum hole for exhausting air from between the compression plates; a support tube provided between the compression plates for sealing a space therebetween, the support tube having an inner space from which air can be exhausted such that an interval between the compression plates can be adjusted; and an exposure unit for hardening the sealant.

13. The in-line system of claim 12 wherein there are provided a plurality of the vacuum holes at predetermined locations, and air is exhausted from the vacuum holes in a predetermined sequence.

14. The in-line system of claim 13 wherein the vacuum holes are formed at corners or center portions of each side of the first and second compression plates.

15. The in-line system of claim 13 wherein the vacuum holes are shaped as slits of a predetermined length.

16. The in-line system of claim 1 wherein the liquid crystal depositing unit includes a liquid crystal depositor that is a syringe-type device such that the liquid crystal material can be deposited at specific predetermined locations in the liquid crystal cell regions.

17. The in-line system of claim 1 wherein the liquid crystal depositing unit is a spray-type device such that the liquid crystal material can be deposited over an entire

surface of the liquid crystal cell regions.

18. The in-line system of claim 1 wherein the sealant-applying unit deposits the sealant in a closed loop, that is, without a liquid crystal injection hole.

19. The in-line system of claim 1 wherein the sealant is a material that is hardened by infrared rays.

20. The in-line system of claim 1 wherein the sealant includes one or more buffer regions that have a predetermined area to allow for flow of excess liquid crystal material.

21. A liquid crystal depositing unit for manufacturing liquid crystal displays, the liquid crystal depositing unit including a depositer for depositing liquid crystal material in liquid crystal cell regions of one of two substrates of a mother glass.

22. The liquid crystal depositer of claim 21 wherein the depositer is a syringe-type device such that the liquid crystal material can be deposited at specific predetermined locations in the liquid crystal cell regions.

23. The liquid crystal depositer of claim 21 wherein the depositer is a spray-type device having a plurality of nozzles such that the liquid crystal material can be deposited over an entire surface of the liquid crystal cell regions.

24. A substrate-attaching unit for manufacturing liquid crystal displays, the substrate-attaching unit attaching, in a vacuum state, two substrates of a mother glass having at least one liquid crystal cell region, thereby completing the manufacture of a liquid crystal panel in which there is provided liquid crystal material.

25. The substrate-attaching unit of claim 24 wherein the substrate-attaching unit includes first and second compression plates for supporting the two substrates and



applying a predetermined force toward each other such that the substrates are pressed together; and an exposure unit for hardening a sealant between the substrates.

26. The substrate-attaching unit of claim 24 wherein the substrate-attaching unit includes first and second compression plates for supporting the two substrates and applying a predetermined force toward each other such that the substrates are pressed together, the first and second compression plates having at least one vacuum hole for exhausting air from between the compression plates; a support tube provided between the compression plates for sealing a space therebetween, the support tube having an inner space from which air can be exhausted such that an interval between the compression plates can be adjusted; and an exposure unit for hardening the sealant.

27. The substrate-attaching unit of claim 26 wherein there are provided a plurality of the vacuum holes at predetermined locations, and air is exhausted from the vacuum holes in a predetermined sequence.

28. The substrate-attaching unit of claim 27 wherein the vacuum holes are formed at corners or center portions of each side of the first and second compression plates.

29. The substrate-attaching unit of claim 28 wherein the vacuum holes are shaped as slits of a predetermined length.

30. The substrate-attaching unit of claim 24 wherein the substrate-attaching unit includes two or more vacuum chambers for conjoining the substrates in a vacuum state in a predetermined in-line process time unit.

31. The substrate-attaching unit of claim 30 wherein the vacuum chambers are connected in series such that the substrates are provided to a subsequent process in a

predetermined vacuum state, each vacuum chamber holding the substrates for a predetermined in-line process time.

32. The in-line system of claim 24 wherein the vacuum chambers are connected in parallel such that the substrates are provided to a subsequent process in a predetermined vacuum state, each vacuum chamber holding the substrates for a predetermined in-line process time.

33. A method for manufacturing liquid crystal displays comprising the steps of:  
dispersing spacers on one of two substrates of a mother glass, the mother glass having at least one liquid crystal cell region;  
depositing a sealant on one of the two substrates;  
depositing liquid crystal material on the substrate on which the sealant is deposited; and

conjoining the substrates in a vacuum state to complete the manufacture of a liquid crystal panel.

34. The method of claim 33 further comprising the step of forming a reaction-preventing layer on a surface of the sealant by a first hardening process such that a reaction between the sealant and the liquid crystal material is prevented.

35. The method of claim 34 wherein the steps of dispersing the spacers, depositing the sealant, depositing the liquid crystal material and conjoining the substrates are performed as in-line processes.

36. The method of claim 35 wherein the steps of dispersing the spacers, depositing the sealant and depositing the liquid crystal material are performed on one of the two substrates.

37. The method of claim 36 wherein the steps of dispersing the spacers and depositing the sealant are performed on one substrate, and the step of depositing the liquid crystal material is performed on the other substrate.

38. The method of claim 34 wherein in the step of conjoining the substrates, the vacuum state is generated in multiple steps of predetermined in-line process time units.

39. The method of claim 34 wherein in the step of conjoining the substrates, the two substrates are provided in the vacuum state in a predetermined in-line process time unit.

40. The method of claim 34 wherein the step of conjoining the substrates includes the steps of aligning the substrates, applying a predetermined force to the substrates in a direction toward each other such that the substrates are attached by the sealant, and exposing the sealant and performing a second hardening process on the sealant.

41. The method of claim 34 wherein the step of conjoining the substrates includes the steps of aligning the substrates, forming a vacuum between the substrates, reducing a space between the substrates by controlling the vacuum, applying a predetermined force to the substrates in a direction toward each other such that the substrates are attached by the sealant, and exposing the sealant and performing a second hardening process on the sealant.

42. The method of claim 41 wherein the step of forming the vacuum is performed through a plurality of the vacuum holes formed at predetermined locations.

43. The method of claim 42 wherein the step of forming the vacuum is performed by exhausting air from the vacuum holes in a predetermined sequence.

44. The method of claim 34 wherein the step of depositing the liquid crystal material includes the steps of providing droplets of the liquid crystal material at predetermined locations, and rotating the substrate.

45. The method of claim 34 wherein the step of depositing the liquid crystal material includes the step of depositing the liquid crystal material over an entire surface of the liquid crystal cell regions.

46. The method of claim 34 wherein in the step of depositing the sealant, the sealant is deposited in a closed loop, that is, without a liquid crystal injection hole.

47. The method of claim 34 wherein the sealant is a material that is hardened by infrared rays.

48. The method of claim 34 wherein the sealant includes one or more buffer regions, which have a predetermined area to allow for flow of excess liquid crystal material.

49. A method for manufacturing liquid crystal displays comprising the step of conjoining two substrates of a mother glass in a vacuum state to complete a liquid crystal panel, the mother glass having at least one liquid crystal cell region, and at least one substrate having liquid crystal material deposited thereon.

50. The method of claim 49 wherein the step of conjoining the substrates includes the steps of aligning the substrates, applying a predetermined force to the substrates in a direction toward each other, adhering the substrates to one another with the sealant, and hardening the sealant to complete the attachment of the substrates.

51. The method of claim 50 wherein the step of completing the liquid crystal panel includes the steps of aligning the substrates, forming a vacuum between the

substrates, reducing a space between the substrates by controlling the vacuum, applying a predetermined force to the substrates in a direction toward each other, adhering the substrates to one another with the sealant, and hardening the sealant to complete the attachment of the substrates.

52. The method of claim 51 wherein the step of forming the vacuum is performed through a plurality of the vacuum holes formed at predetermined locations.

53. The method of claim 52 wherein the step of forming the vacuum is performed by exhausting air from the vacuum holes in a predetermined sequence.

54. The method of claim 50 wherein in the step of completing the liquid crystal panel, the vacuum state is generated in multiple steps of predetermined in-line process time units.

55. The method of claim 50 wherein in the step of completing the liquid crystal panel, the two substrates are provided in the vacuum state in a predetermined in-line process time unit.